Video Captions for Online Courses: Do YouTube's Auto-generated Captions Meet Deaf Students' Needs?

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Abstract

Providing captions for videos used in online courses is an area of interest for institutions of higher education. There are legal and ethical ramifications as well as time constraints to consider. Captioning tools are available, but some universities rely on the auto-generated YouTube captions. This study looked at a particular type of video—the weekly informal news update created by individual professors for their online classes—to see if automatic captions (also known as subtitles) are sufficiently accurate to meet the needs of deaf students. A total of 68 minutes of video captions were analysed and 525 phrase-level errors were found. On average, therefore, there were 7.7 phrase errors per minute. Findings indicate that auto-generated captions are too inaccurate to be used exclusively. Additional studies are needed to determine whether they can provide a starting point for a process of captioning that reduces the preparation time.

Keywords: online; distance education; Deaf; accessibility; videos; captioning; subtitles; YouTube

Literature review

Captions, once a rarity, are now prevalent in today's media, especially in television programming. They are sometimes referred to as subtitles and are generally considered to be a textual representation of a video's audio message (*Caption it Yourself*, n.d.) This definition is not entirely accurate because captions can also translate visual languages such as American Sign Language (ASL) to a written language such as English (Matthews, Young, Parker, & Napier, 2010). In these cases there might be no audio track. However, for the purposes of this discussion, the focus is on captions that represent spoken languages.

In addition to televised shows, captioned films are available in some movie theatres and many captioned videos are available on the web. There are two styles of captioning—open captions and closed captions. Open captions are integrated with the video and cannot be turned off, whereas closed captions are read by the media player and can be turned on or off according to the user's preference (Clossen, 2014). Captions are usually regarded as a tool to benefit people who are deaf or hard of hearing although many other groups of learners, including second-language learners, also use them (Collins, 2013). The focus of this discussion will be on web-based videos, especially those used in higher education settings.

Using videos in higher education

The number of colleges and universities offering online classes continues to increase; 32% of students in the United States are reported to be enrolled in at least one (Sheehy, 2013). Many universities have fully online degree programmes and the trend towards fully online courses is likely to continue for the foreseeable future. In addition, there has been an increase in the number

of massive open online courses (MOOCs) offered by universities. MOOCs are free online courses that are offered without admission criteria (Anastasopoulos & Baer, 2013). Traditional classes and MOOCs often use videos to encourage students to establish connections and share content. The videos in these courses vary greatly—from professionally created and edited lectures, to informal announcement-style 'talking heads', to screencast tutorials. Many courses also embed videos that are available in popular media—for example, from TED Talks, Khan Academy, and others (Fichten, Asuncion, & Scapin, 2014).

Online courses are not the only ones affected by the issue of captioning videos. For example, some face-to-face classes use a technique called lecture capture to record live lectures and make them available electronically for students to use as a review or, in some cases, as a substitute for class attendance (Newton, Tucker, Dawson, & Currie, 2014). These multimedia presentations often include the presenter's audio and accompanying presentation slides. Many current approaches to lecture captioning do not provide captions for the video components (Newton et al., 2014).

Rationale for captioning videos in higher education

Many faculty members want to create courses that are accessible to all their students, but the issue of captioning videos goes beyond individual concern and has become a legal matter for universities. Two laws in the United States provide a guideline for educational institutions. Section 504 of the Rehabilitation Act 1973 prohibits a college from denying disabled individuals any benefits. Title II of the Americans with Disabilities Act 1990 says that individuals with disabilities may not be excluded or denied the benefits of the service of public universities and colleges (Anastasopoulos & Baer, 2013). Although both of these laws were written before the explosion of web-based multimedia, they are the basis for the US Department of Education's Office for Civil Rights' policy "… that an institution's communications with persons with disabilities must be as effective as the institution's communication with others" (Anastasopoulos & Baer, 2013, p. 2). There is also some ambiguity about the practical interpretation of "undue burden". This term is defined in the Americans with Disabilities Act as "significant difficulty or expense" (Americans with Disabilities Act 1990, Title III), but is ambiguous in certain circumstances. In addition, the World Wide Web Consortium has established web content accessibility guidelines, and one of their recommendations is that all pre-recorded audio be captioned (Anastasopoulos & Baer, 2013).

There are legal ramifications for universities that do not provide captioning for videos. A recent lawsuit by the National Association of the Deaf (NAD) accused Harvard and MIT of offering MOOCs and many individual videos to the public without captioning ("Lawsuits ask Harvard", 2015). The NAD reported that video captions for MOOCs run by Harvard and MIT were often missing—or present but inaccurate to the point of being unintelligible—so violating the Americans with Disabilities Act and the Rehabilitation Act.

One way to relay the audio information in a video is to provide a script, usually in the form of a Word document or a PDF file. However, that solution does not take into account the benefits of synchronising the video and verbal content (Closlen, 2014; Parton & Hancock, 2009). Therefore, "if transcripts are the letter of the law … then captions are the spirit [of the law]" (Closlen, 2014, p. 32).

Creating captions

As videos become commonplace in online courses offered by institutes of higher education, and there is a legal and ethical need to caption those videos for the benefit of all students (but especially those who are deaf and hard of hearing), the issue becomes one of how to provide the

captions. The full range of options for creating captions is outside the scope of this article, but a brief overview of popular techniques will serve the discussion.

First, universities can choose to outsource the role of captioning to a professional company. This option can be expensive and requires lead time. It might work for key lectures, but might not be feasible for more frequent and informal communication (Johnson, 2014). Pay-per-use services such as SynWords (Dubinsky, 2014) have similar limitations.

Second, a professor can choose to manually caption videos using one of several tools that are available for free or purchase. The process typically involves synching a script (pre-existing or created on the fly) with time points in the video. Media Access Generator (MAGpie) was the original free caption-authoring tool—although robust, it does require a relatively steep learning curve (Parton, 2004). Subtitle Workshop is another popular free tool that can be downloaded and used to create a caption file (*Caption it Yourself*, n.d.). Amara, which is browser-based, is easy to use. The user interface design is typical of caption-authoring tools and provides a space for the captions to be entered and a timeline to sync the captions with the audio. Third-party tools usually create a separate file for the captions, although Amara instead publishes the new captioned video on their own server. The need for these and other tools has diminished since YouTube integrated its own captioning tool. Users can now add a language track to their YouTube videos (Carlisle, 2010).

The ongoing development of the You Tube auto-captioning tool has created a third path for professors and the focus of the current study. Instead of manually captioning videos, they can now take advantage of YouTube's auto-captioning feature in which text-to-speech software generates the captions without human intervention (Fichten et al., 2014). This method of captioning is the quickest option available to professors, but the issue of accuracy has been debated. In a recent panel discussion during the IT Accessibility in Higher Education Conference, students noted that professors were relying on YouTube's auto-generated captions and expressed concern about accuracy (Bennett, Wheeler, Wesstrick, Teasley, & Ive, 2015). Still, a national study of deaf students (*N*=95), found that 85 of the participants preferred to watch videos with captions generated from automatic speech recognition than to have no captions (Shiver & Wolfe, 2015). This scenario leads to a situation where auto-generated captions may be seen as an acceptable alternative by deaf users, but "deaf advocacy groups could be concerned that organizations may attempt to substitute automatic captions [for professionally created ones] in order to meet legal obligations" (Shiver & Wolfe, 2015, p. 237).

Auto-generated YouTube captioning feedback

The US Department of Education's Office for Civil Rights lists "accuracy of the translation" as one of their criteria for determining whether a university's communication is effective for people who need captions, such as those who are deaf or hard of hearing (Anastasopoulos & Baer, 2013). There is limited and varying research in the literature on the accuracy of YouTube's auto-generated captioning in educational settings. Johnson (2014) reports "[t]he automatic captions are notoriously inaccurate, leading to the creation of an Internet meme known as 'YouTube Automatic Caption FAIL' wherein users post humorous examples of YouTube captions that don't match the actual audio content" (p. 11). In response to an article on MOOCs (Anastasopoulos & Baer, 2013), a deaf reader responded that she was devastated to see how many videos in these courses were relying on YouTube's auto-captioning because they were full of errors and did not have proper timing. Other researchers have been less critical. While still acknowledging the limitations of the tool, they report it is an easy solution that reduces the time-consuming work of manually creating the captions, but that the results are sometimes unintentionally humorous (Clossen, 2014). Suffridge & Somjit (2012) have found "[w]hile YouTube captioning is not 100% accurate, it does do a fairly good job" (p. 3). A frequent

recommendation is to start with the auto-captions and then edit to reduce the number of errors and fix any timing issues (Clossen, 2014; Johnson, 2014).

The study

The guiding question for this research study was: Do auto-generated YouTube captions meet the needs of students? In the spirit of Universal Design for Learning (UDL), captions can be beneficial to a wide range of students (Clossen, 2014); however, this study focuses primarily on this question through the lens of a deaf student. The term 'deaf' here refers to individuals who are both culturally Deaf (i.e., individuals who self-identify as part of a cultural and linguistic minority) and/or those who are physically deaf or hard of hearing. The term 'meet the needs' is rather ambiguous and is a topic for further discussion but in practical terms, and in this context, it refers to the accuracy of the captions.

Although online college courses use many types of videos, the ones chosen for this study were casual weekly videos made by one professor. Weekly videos make students feel more connected to the instructor and are easy to produce with a cell phone or web cam (Suffridge & Somjit, 2012). While the videos might not contain critical course content, they do provide an important social presence between professors and students. It would not be feasible, in terms of time or cost, to professionally caption these videos, yet they often contribute significantly to the positive atmosphere of an online course and must therefore be accessible.

Methods

The first step in this study was to obtain a series of bi-weekly videos that were professor-made and used in online courses. Because they met the study's criteria, the author's own materials were selected. All of the announcement video links were supplied for three graduate-level courses in the 15-week spring semester of 2015. The total number of videos created for the semester was 21 (seven per class). There was a total of 68 minutes of video in the 21 segments. All of the videos were made on a laptop with a built-in webcam and built-in microphone. No editing was performed on the videos other than adding basic border frames. The videos had been uploaded to YouTube and then embedded in Blackboard, the course management system. No attempt was made to use or check the auto-generated captions because no deaf students were enrolled and no other students expressed a need for captions.

The next step was to analyse each video and its auto-generated captions for errors. The literature did not reveal a standard approach (in legal or practical terms) for determining the criteria for considering the captions' accuracy. Although errors could be minor misspellings or text such as filler words (e.g., "um") that did not exactly match the speaker, those issues do not commonly affect comprehension in isolation. Therefore, the decision was made to look at phrase-level errors—those that altered the meaning of the message or made the message unintelligible. Thus, as each video was played, a record was made of each phrasing error, but grammatical errors, misspellings, and minor word changes were omitted. Although there was some subjectivity in this approach, it provided a holistic view of the state of the videos' captions and allowed researchers to focus on the critical components.

Results

The number of phrase errors in the video captions was substantial. A total of 525 such errors were recorded during the 68 minutes. This means that for every minute there were 7.7 phrases

that were unintelligible or altered the meaning of the message. Table 1 shows 50 of those errors. The complete list of 525 errors can be viewed as raw data in the project data spreadsheet.[1]

Table 1 Sample caption errors

Audio phrase	Captioned phrase
Spring semester	Springs the minister
I've taught this one	Topless one atom
One wonderful kitty	Wonderful kidding
To reply to a classmate	To rip apply to a classic am
A movie chat session	Move in chess session
Classroom for the deaf	Classroom for the debt
New edition	New dish
Not getting paid from Amazon	Have had making paper metal
Kinda dating myself there	And can and a mess up there
I had to code	Ahead to coat
Where I learned Adobe Premiere	World anti-doping from here
Do something fun	Get to the summit bar
Did for Deaf president now	That they didn't protect president now
And keep building on that	Can't keep Billy
Gave you link for	Didn't foreign still unit
Look at 10 to 15 of them	Like unit in anti-government
And good stuff on blackboard	It's tough black
Dr. Martin Luther King Jr.	With the key engineer
Now we think laptops and cell phones	Our with the game at pops open
And all that kind of good stuff	And Iraq and stuff
Can always email me	Can only mailman
And I think it relates	And at the gate
I wanted to	I lied to
But I encourage you	Bankers you
Google chat	People jet
Narrow anything down	Row anything to him
Here are my thoughts	Have here's carol come apart from
Cost associated with	Some pasta associated with
Used my student loans	Miss you London
To all of you	I love you

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[1] See Captioningerrors
https://docs.google.com/spreadsheets/d/1IZVi74wUJH4HK9oL_2GQlfizAcYJFZOl9drEZDRbDB4/edit?pref=2&pli=1#gid=0

Alright, enjoy	RN injury
Happy Valentine's Day	Heavy bond on
And I	[swear word inserted instead]
I choose	iTunes
Lesson plan	Let them play 'em
Hi folks	Hyper X
Active presenter	Active prisoner
Some of our own students	The Maroons didn't then doing
Over spring break	Overseas
Hi guys	White guys
The big conference, ISTE	The camera is Steve
1 more module	1 more macho
5 of them will be for	But I don't know be four
Critiques, you are going to put straight on	Crunchy chicken constraint
Fun chapters	Punch actors
Towards the end	Toys into the
For some doc interviews	Person docking abuse
Taught a whole course	Have tomahawk or
You can	UK inch
The end	Indian

The errors were produced in all of the videos—none had notably more, although the number ranged from 2.5 to 13.3 errors per minute. Table 2 breaks down the data per video.

Table 2 Video caption errors per minute

Video ID	Length of video	# of phrase errors	Errors/minute (rounded)
1	7:25	55	7.3
2	9:41	73	7.5
3	4:52	52	10.4
4	3:03	40	13.3
5	7:01	60	8.6
6	1:22	11	7.3
7	1:49	16	9.1
8	4:11	25	5.9
9	2:24	21	8.4
10	2:01	7	3.5
11	2:00	5	2.5

12	3:08	15	5.0
13	1:56	10	5.0
14	3:02	15	5.0
15	2:05	16	8.0
16	1:58	7	3.5
17	1:31	20	13.3
18	2:54	34	11.3
19	1:47	14	8.0
20	2:46	18	6.5
21	0:58	11	11.0
	68 minutes	525 errors	7.7 avg errors/min

The types of errors found in this analysis reveal serious issues in the auto-captioning process. See Figure 1 for a sample of screenshots depicting the inaccurate subtitles.
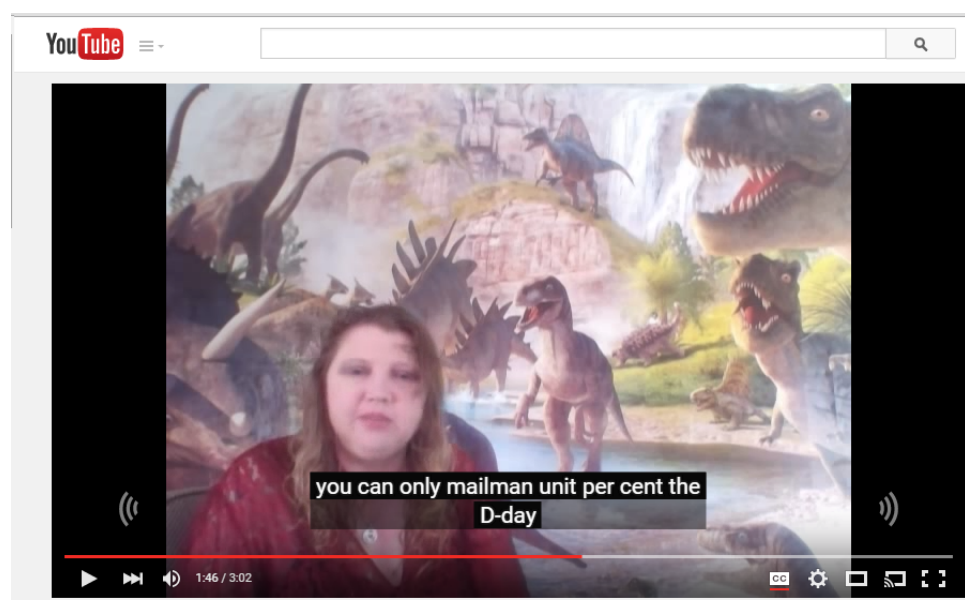

Figure 1 Sample of captioning error for the audio message: "You can always email me. I have the due dates."
EDTC628-MajorProject1_spring15 Retrieved from https://youtu.be/L-84wctzvRU
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In two of the 525 cases, the YouTube subtitle showed a swear word that was clearly not said by the professor. In other cases the captions were similar to the audio, but the meaning was altered significantly by a minor error. For example, the phrase '3 to 5 questions' was shown as '35 questions'. Some of the errors were to be expected due to the use of proper nouns for names and places, but these did not comprise a substantial proportion of the phrase-level errors. Many of the errors, as one might expect, occurred when a wrong word was substituted for the right one because they sounded alike—such as 'the end' becoming 'Indian'. These associations make no sense to an individual who is deaf and does not read by 'sounding the words out'. In addition to the phrase-level errors, the grammatical and syntactical errors were too numerous to consider for

14

this study. The filler word "um" was often displayed as "am", spellings were at times displayed as short cuts (e.g., "r" for "are"), tense was often shown wrongly, words such as "two" and "to" were used as though they had the same meaning, and so on.

Discussion and limitations

Some limitations to this study might have affected the generalisability of the results. Only one professor's videos were analysed; the study does not, therefore, take into account other speakers' accents, which could influence the phrase error rate. The sound quality and the equipment used to record the videos was typical of the setup that a professor would use to record weekly news updates, but different software, microphones, and speaker positioning could lead to a different rate of accuracy for the auto-generated captions. The issue of sound quality could be the basis for a future study. In addition, this study focused solely on bi-weekly informal videos, but professors often create a wide range of materials for their classes, including narrated screencasts, mini lectures, and feedback clips. It would be interesting to see how other types of video compare in an analysis of captioning errors. A recommendation for a future study would be to involve deaf individuals in the evaluation process to provide feedback and insight.

Professors are often under time constraints when developing and/or teaching a course (Freeman, 2015) so it is imperative to find a balance between the need for reliable captions and the ability to provide those captions quickly. However, results from this study indicate that, in most situations, auto-generated captions might not 'meet the needs' of deaf students in terms of providing accurate subtitles. In practical terms, the 7.7 phrases per minute that were unintelligible or altered the meaning of the message meant that the essence of the message was not understandable. The errors were so frequent that they were more than distracting—they were a barrier to communication. Without editing, the auto-captions would not appear to meet the Office for Civil Rights criteria for communication that is as effective for people with disabilities as for those without. Universities are therefore unlikely to be meeting their legal obligation to provide accessible material.

Although captions created entirely by a human may be ideal—especially when the content is highly technical—edited auto-generated captions could play a role in conversational-style, weekly news videos created by professors. More research needs to be conducted to see if the time requirement for editing the auto-generated captions is feasible compared with manual captioning. Although the concept of crowdsourcing captioning (whereby other students in the class modify auto-generated captions) is a very new idea, it could also play a role in future discussions on time management and legal ramifications (Deshpande, Tuna, Subhlok, & Barker, 2014).

It would also be interesting to study the degree to which speech-to-text engines have become more accurate over time (it is 5 years since YouTube introduced the auto-captioning feature). An investigation could look at videos that have produced inaccurate captioning results in the past and see if the same errors occur if they are re-captioned today. An additional study could focus on the accuracy of the translations that are used in subtitles for other languages.

Broader implications

This study looked at captioning and accessibility primarily in relation to the needs of deaf individuals. However, there are implications for a far wider range of students. The concept of Universal Design for Learning (UDL) is that course materials are set up ahead of time to incorporate learning paths for everyone, rather than accommodating a specific user later on (Poothullil, Sahasrabudhe, Chavan, & Toppo, 2013; Tobin, 2014). The three principles of UDL are: 1) to provide multiple means of representation; 2) to provide multiple means of action and

expression, and; 3) to provide multiple means of engagement (*Three Principles of UDL*, n.d.) These principles can also apply to the concept of captioning. According to Tobin (2014, p. 17) "[c]aptions can help the vast majority of students". Tobin identifies some of these students as second-language learners, those who are studying in quiet places such as a library, and those who process content better via text.

Accessibility affects students of every nationality. While many countries have legal requirements for captioning for both the general public and students, others do not. In India, for example, there is no mandatory captioning (Poothullil et al., 2013), although there is recognition of the benefits of captioning—including as a tool for reading practice to combat the high illiteracy rate (Poothullil et al., 2013). One can see that, if captions are to be used in this manner, they must be accurate. Time and cost, however, remain a concern for many. For example, in Japan's corporate sector there is a desire to provide real-time captioning that is not as costly as a stenographer. One current research study seeks to combine automated speech recognition software with manual editing that can be accomplished by a non-expert rather than a trained stenographer (Takagi, Itoh, & Shinkawa, 2015). This scenario appears similar to that of the professor (a non-expert) combining their manual edits with the auto-captioning results.

Another broad implication of this study relates to the idea of meeting the needs of students. Does the (in)accuracy of video captioning truly embrace that concept? Even accurate captions will not meet students' needs if they cannot read and comprehend them. "Producers of captions and educators have both been concerned whether individuals who are deaf are able to understand captions that are presented at relatively fast speeds and that sometimes contain complex grammatical forms" (Stinson & Stevenson, 2013, p. 453). The limited reading proficiency of some people who are deaf, and for whom English is often a second language, has long been noted to correlate with their ability to comprehend captions (Cambra, Silverstre, & Leal, 2009; Stinson & Stevenson, 2013). Multiple studies have focused on modifying captions to address this issue; for example, by reducing language complexity in the captions, slowing the caption rate, and embedding expanded information in the captions. This extra information might be hyperlinks to define key words, or to provide illustrations (Stinson & Stevenson, 2013). Other researchers have argued that the way to ensure effective communication is to provide an interpreted video when the student's primary language is ASL (Parton & Hancock, 2009). (An interpreted video is one in which a human signer or, in some cases, an animated avatar, translates the audio content into a particular sign language.) Although such efforts are outside the scope of the current study, it is worth considering whether captions—auto-generated or not, much like script files, may be serving the letter, but not the spirit, of the law.

In practical terms, these extended measures are probably too complicated to perform on routine weekly video updates produced by professors who often have little or no technical background or experience in working with individuals who are deaf. Thus, given the time and technical constraints, YouTube's auto-generated captioning may be a viable start to a solution for professors who want to create informal, accessible video updates. However, because it would not meet the legal requirements established by universities in many countries, nor fulfil the spirit of UDL, it is only a partial solution and should not be relied on exclusively.

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